Characterization and Modeling of Inherent Optical Properties in the Gulf of Maine

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LONG TERM GOALS

Our long term goal is to contribute to a fundamental understanding of the sources of biological, physical and optical variability in coastal ocean systems. Particular focus is on applications useful for studying important ecological processes and the links between phytoplankton properties and physical processes in coastal regions.

OBJECTIVES

The overall objective of this project is to improve understanding of the Gulf of Maine and Georges Bank system through characterization and modeling of optical properties in the context of physical and biological processes. We wish to describe the processes controlling space/time variability in the various constituents (CDOM, phytoplankton, sediment, detrital particles) that determine the optical properties of this region. Specific objectives fall into two categories:

Observational/Database Objectives

- Complete processing and quality control for optical and hydrographic data collected during 5 cruises to the GOM during 1997-1999,
- Compile a readily accessible database of spectral optical properties for the GOM from these cruises, as well as other recent research programs,
- Use the database to develop parameterizations of optical variability that will be used in the numerical simulations;

Modeling Objectives

- Implement a hierarchy of optical models (from CDOM as a single passive tracer to a full ecosystem model with optical linkages) into the three-dimensional circulation model; conduct

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14. ABSTRACT
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15. SUBJECT TERMS

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“process-oriented” simulations to examine how the relative contributions of the various optical constituents vary spatially and temporally,

- Construct data-driven hindcast simulations based on field data from 1997-1999; use the coupled models to distinguish spatial from temporal variability in the observations.

APPROACH

Optical properties have potential to provide information about biological and chemical constituents present in coastal ecosystems, however, signals can be difficult to interpret because of the complexity and multidimensional (time, space, wavelength) nature of the relevant processes. Three-dimensional modeling offers an attractive framework for synthesis and understanding of the factors contributing to optical variability. We are taking advantage of an extensive optical dataset collected in previous work by one of us and a realistic three-dimensional circulation model coupled to an ecosystem model by the other. Our new work will include development of methods to parameterize optical variability (based on observations) within a hierarchy of models from a single passive tracer to full coupling with the ecosystem model. “Process-oriented” simulations and hindcast simulations with data assimilation will be used to examine how the relative contributions of different optical constituents vary and to distinguish spatial from temporal variability.

WORK COMPLETED

Our effort for the first 9 months of this project has concentrated on the initial Observational/Database objectives. As planned, we have completed the processing and quality control for nearly all of the optical and hydrographic data collected during 5 cruises to the GOM during 1997-1999. This includes ac-9 data (spectral absorption and scattering), Hydroscat-6 data (spectral backscattering), radiometric data (spectral downwelling irradiance and upwelling radiance), and discrete measurements of pigment concentration and absorption spectra (particles and dissolved material).

We have also made a great deal of progress towards compiling an accessible database that includes not only our observations, but those collected by several other investigators working in the Gulf of Maine region. This work has involved identifying available data, communicating with the investigators, and then generating software to facilitate handling various data types. As part of this effort we have also been continuing to work with SeaWiFS data from our cruise periods.

The compiled database is now being used to generate empirically driven parameterizations of optical variability for the Gulf of Maine region that will used to construct an optical submodel (to later be coupled with the biological and physical models). We have just begun this work and will continue to focus on this aspect in the coming months.

Linkage between the observational and modeling components of this work will begin in earnest during year 2. Relevant modeling activities that we carried out during year 1 were supported as part of McGillicuddy's YIP; see 2001 annual report for McGillicuddy’s grant (“BCmcgillicuddy01”) for more details.

RESULTS

The database of optical observations we have compiled currently includes results from 3 principal investigators and 12 research cruises plus more than 30 underway transects. The observations cover many areas of the Gulf of Maine and most months of the year (Fig. 1).

Our preliminary efforts to characterize optical variability present in the Gulf of Maine at different times of year have documented that, even in surface waters, some properties must be considered seasonally variable, while others seem more stable. We found that the magnitude and spectral shape of the chlorophyll specific absorption coefficient for phytoplankton is highly variable (presumably due to changes in the light acclimation and/or species composition of the community), while the spectral dependence of the particle backscattering coefficient and the absorption coefficient for detrital material are relatively constant (Fig. 2). These observations will be quantitatively incorporated into the optical model we are constructing.

Our work with SeaWiFS data from the Gulf of Maine continues to be hampered by problems with atmospheric correction approaches, however, we have completed a manuscript on the approach we plan to use for optically identifying water masses (Martin Traykovski and Sosik, submitted).

Recent results from the biological-physical modeling work (which are directly relevant to this project) are presented in McGillicuddy's annual report mentioned in the previous section.

IMPACT/APPLICATIONS

Coastal ecosystems are highly complex and multidimensional. Understanding how they function and determining the important spatially and temporally varying processes that regulate them requires interdisciplinary and multi-faceted approaches. The combination of detailed spatially-resolved observations and 3-dimensional modeling (with data assimilation) has great potential to contribute to answering these questions. Optical properties contain a lot of information about biological and chemical aspects of a coastal system. They cannot be accurately interpreted, however, without considering time-varying physical processes, which are directly responsible for moving material around and indirectly important through their role in regulating biological and chemical processes. Integration of models of optical properties into our physically realistic ecosystem simulations will contribute to better understanding of the processes contributing to optical variability in coastal waters.

TRANSITIONS

Characteristic inherent optical properties based on our observations have been provided to Howard Gordon at RSMAS as part of an on-going interaction to improve processing methods for SeaWiFS data from the Gulf of Maine.

AOP and IOP data, collected in 1997, 1998 and 1999 in Gulf of Maine; submitted to World Wide Ocean Optics Database (WOOD), contact: Jeffrey Smart.

AOP, IOP and pigment data, collected in 1997, 1998 and 1999 in Gulf of Maine; submitted to NASA SeaWiFS Bio-Optical Archive and Storage System (SeaBass) database, contact: Sean Bailey.

AOP and IOP data and pigment, collected in 1997, 1998 and 1999 in Gulf of Maine; submitted to the National Ocean Data Center (NODC).

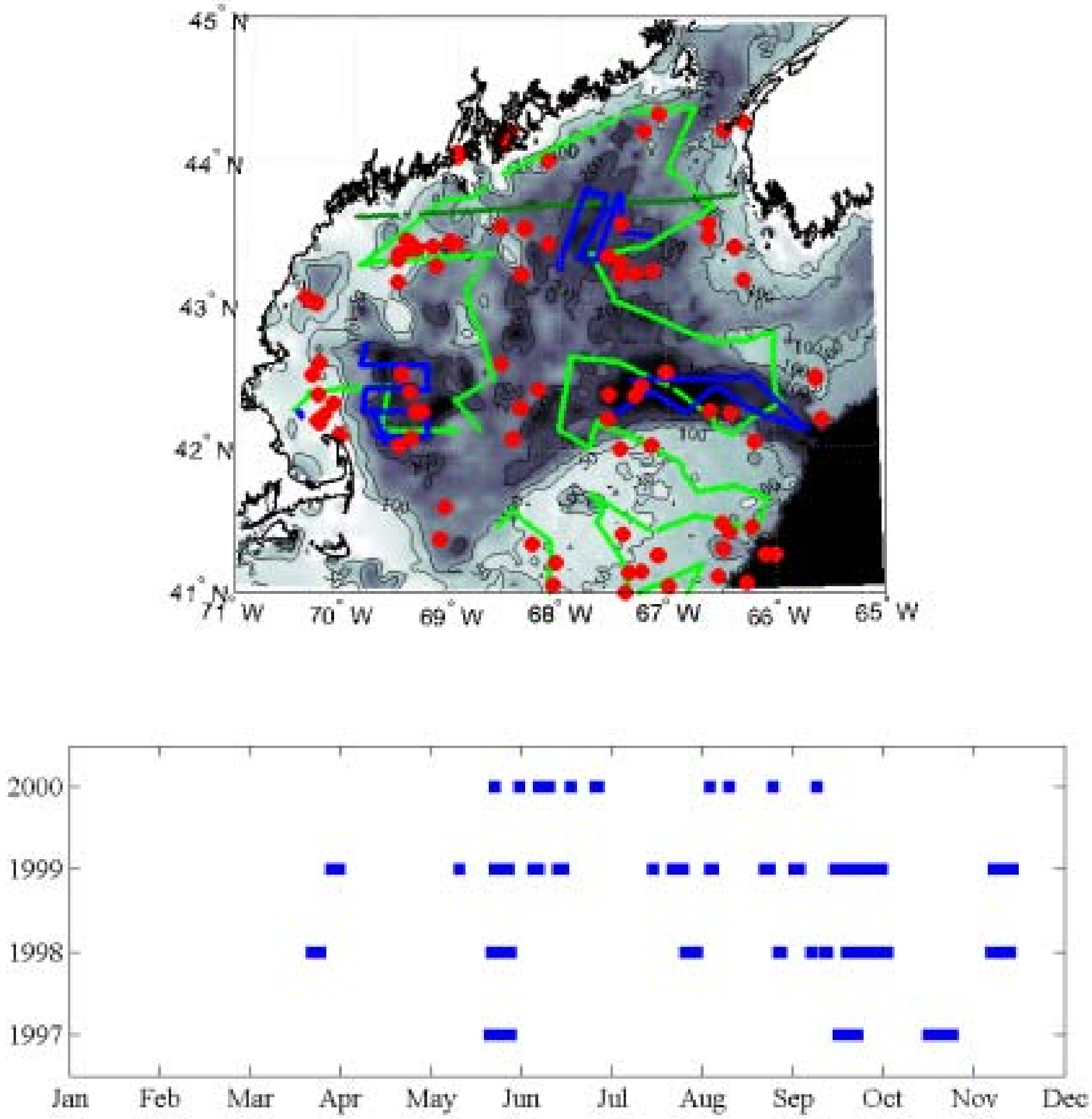

Figure 1. Spatial (upper) and temporal (lower) distribution of optical observations compiled from a variety of research programs sampling the Gulf of Maine and Georges Bank region. In upper panel, red points correspond to stations occupied during various cruises led by D. Phinney, blue lines indicate a typical cruise track for our 5 towed vehicle surveys, and green lines show underway surface surveys by W. Balch. We expect to incorporate all of these observations as we develop and evaluate parameterization of optical properties for our modeling work.

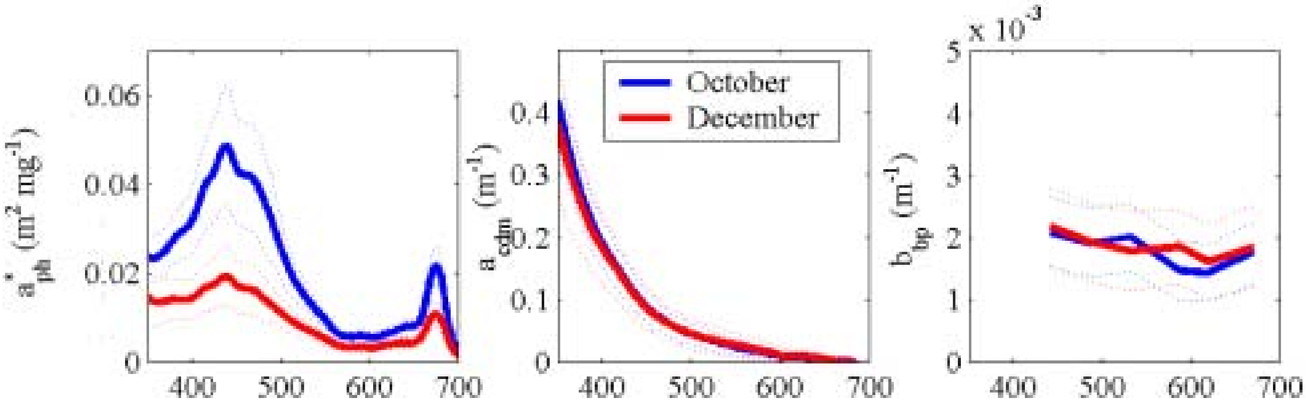

Figure 2. Average spectral inherent optical properties from observations in the Gulf of Maine during October and December. Mean values +/- one standard deviation (dotted lines) are also shown. The results show that specific absorption for phytoplankton (left) is much higher in autumn than in winter months, while absorption by detrital material (middle) and backscattering by particles (right) are similar between the two seasons. These observations were collected during our BIOMAPER II cruises (see Sosik and Morrison 2000).

RELATED PROJECTS

This project is closely related to on-going work in the McGillicuddy laboratory supported by the ONR YIP program ("Physical Forcing of Phytoplankton Abundance in the Gulf of Maine – Georges Bank Region"). Our new work will build directly on these on-going modeling efforts.

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